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EVALUATION OF SAMPLING AND ANALYTICAL METHODS FOR NICOTINE AND POLYNUCLEAR AROMATIC HYDROCARBON IN INDOOR AIR

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The objective of this project was to evaluate a potential collection medium, XAD-4 resin, for collecting nicotine and polynuclear aromatic hydrocarbon (PAH) and to determine whether one collection system and one analytical method will allow quantification of both compound classes in air. The extraction efficiency study was to determine the extraction method to quantitatively remove nicotine and PAH from XAD-4 resin. The results showed that a two-step Soxhlet extraction consisting of dichloromethane followed by ethyl acetate resulted in the best recoveries for both nicotine and PAH. In the sampling efficiency study, XAD-2 and XAD-4 resin were compared, in parallel, for collection of PAH and nicotine. Quartz fiber filters were placed upstream of both adsorbents to collect particles. Prior to sampling, both XAD-2 and XAD-4 traps were spiked with known amounts (2 μg) of perdeuterated PAH and D_3-nicotine. The experiments were performed with cigarette smoking and non-smoking conditions. The spiked PAH were retained well in both adsorbents after exposure to more than 300 m^3 of indoor air. The spiked XAD-4 resin gave higher recoveries for D_3-nicotine than did the spiked XAD-2 resin. The collection efficiency for PAH for both adsorbents is very similar but higher levels of nicotine were collected on XAD-4 resin.

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FOREWORD

Measurement and monitoring research efforts are designated to anticipate environmental problems, to support regulatory actions by developing an indepth understanding of the nature and process that impact health and the ecology, to provide innovative means of monitoring compliance with regulations, and to evaluate the effectiveness of health and environmental protection efforts through the monitoring of long-term trends. The Environmental Monitoring Systems Laboratory, Research Triangle Park, North Carolina, has responsibility for assessment of environmental monitoring technology and systems, implementation of agency-wide quality assurance programs for air pollution measurement systems, and supplying technical support to other groups in the Agency including the Office of Air and Radiation, the Office of Toxic Substances, and the Office of Solid Waste.

The determination of human exposure to toxic organic compounds is an area of increasing significance to EPA. Since cigarette smoking is one of the major contamination sources for PAH and nicotine is a potential marker for cigarette smoke, the evaluation of a potential collection medium, XAD-4, for nicotine and polynuclear aromatic hydrocarbons (PAH) and determination whether one collection system and analysis will allow quantification of both compound classes can provide important information relevant to monitoring indoor air pollution.

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ABSTRACT

The objective of this project was to evaluate a potential collection medium, XAD-4 resin, for collecting nicotine and polynuclear aromatic hydrocarbon (PAH) and to determine whether one collection system and one analytical method will allow quantification of both compound classes in air.

The extraction efficiency study was performed to determine the extraction method to quantitatively remove nicotine and PAH from XAD-4 resin. Various solvents were used with both the solvent-spiking and XAD-4 matrix-spiking methods. The results showed that a two-step Soxhlet extraction consisting of dichloromethane followed by ethyl acetate resulted in the best recoveries for both nicotine and PAH.

In the sampling efficiency study, XAD-2 and XAD-4 resin were compared, in parallel, for collection of PAH and nicotine. Quartz fiber filters were placed upstream of both adsorbents to collect particles. Prior to sampling, both XAD-2 and XAD-4 traps were spiked with known amounts (2μg) of perdeuterated PAH and D_3-nicotine. The experiments were performed with cigarette smoking and non-smoking conditions.

Indoor air was sampled for 24 hrs at a nominal flow rate of 8 cfm. The XAD-2 and XAD-4 samples were extracted with dichloromethane followed by ethyl acetate and analyzed by gas chromatography/mass spectrometry (GC/MS).

The spiked PAH were retained well in both adsorbents after exposure to more than 300 m^3 of indoor air. The spiked XAD-4 resin gave higher recoveries for D_3-nicotine than did the spiked XAD-2 resin. The collection efficiency for PAH for both adsorbents is very similar but higher levels of nicotine were collected on XAD-4 resin. Thus, the sampling module containing the quartz fiber filter and XAD-4 resin in series is recommended for the future field study. Positive chemical ionization gas chromatography/mass spectrometry (PCI GC/MS) in the multiple ion detection mode (MID) proved to be a very sensitive method for the determination of both nicotine and PAH. We concluded that one collection system and one analytical method can be used to determine PAH and nicotine in indoor air.

CONTENTS

Foreword iii
Abstract iii
Acknowledgement iv
Acknowledgement vii

1. Introduction 1
2. Conclusions 3
3. Recommendations 4
4. Experimental Procedures 5

Preparation of Adsorbents 5
Extraction efficiency study 5
Sampling efficiency study 7
Gas chromatography/mass spectrometry (GC/MS) 9

5. Results and Discussion 13

References 24

TABLES

Number		Page
4.1	Cleanup Methods for XAD-4 Resin	6
4.2	The Spiking Solution Used in the Extraction Efficiency Study	6
4.3	Types of Solvents Evaluated in the Extraction Efficiency Study	7
4.4	The Spiking Solution Used in Sampling Efficiency Study	8
4.5	Summary of the Sampling Condition	8
4.6	Sampler Cigarette Exposure Times	9
4.7	GC/MS Operating Condition	10
5.1	Recovery Data of PAH and Nicotine from Extraction Solvent Spike Study	14
5.2	Recovery Data of PAH and Nicotine from Extraction Matrix Spike Study	15
5.3	Levels of PAH and Nicotine Found in XAD-2 and XAD-4 Samples Collected Simultaneously	18
5.4	Levels of PAH and Nicotine Found in XAD-2 and XAD-4 Samples Collected Simultaneously	19
5.5	Levels of PAH and Nicotine Found in XAD-2 and XAD-4 Samples Collected Simultaneously	20
5.6	Levels of PAH and Nicotine Found in XAD-2 and XAD-4 Samples Collected Simultaneously	21
5.7	Levels of PAH and Nicotine Found in XAD-2 and XAD-4 Samples Collected Simultaneously	22
5.8	Recovery Data for Perdeuterated PAH and Nicotine from XAD-2 and XAD-4 Samples	23

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SECTION 1

INTRODUCTION

Many polynuclear aromatic hydrocarbons (PAH) are mutagens, carcinogens, or both. There is increasing concern over human exposure to these compounds in indoor air from the workplace, home and school.

Several studies have identified environmental tobacco smoke (ETS) as a major contributor to levels of PAH in indoor air pollution. Battelle conducted a pilot study to determine PAH in residential air (Chuang, et al., 1985). The results indicated that cigarette smoking is one of the major contributors to levels of PAH. The study found higher levels of particulate matter and PAH in homes occupied by smokers. Other studies (Lewtas et al., 1987 and Lorfroth et al., 1983) have also indicated that cigarette smoking can substantially increase the mutagenicity of the indoor air.

It appears that nicotine can be an important marker for ETS because it is unique to tobacco smoke and is a major constitutent of the smoke. However, it is not clear whether air sampling and analytical methods typically used for PAH can be applied to nicotine. Different collection media such as treated filters, which require separate sample preparation and analyses, are normally used to determine nicotine in air (Hammond et al., 1987). It is desirable to determine both compound classes in indoor air with only one collection system and analysis method.

The following study was carried out to evaluate a potential collection medium, XAD-4 resin, for nicotine and PAH and to determine if one collection system and analytical method can be used to determine both compound classes. This study consisted of the following subtasks:

1. Extraction efficiency studies to determine the optimum procedure for determination of nicotine and PAH.

2. A sampling efficiency study under cigarette smoking and non-smoking conditions, using a filter and either XAD-4 or XAD-2.
3. Evaluation of different analytical methods to measure nicotine and PAH to determine if nicotine and PAH can be measured within one analysis.

SECTION 2

CONCLUSIONS

The following conclusions are based on the results of this study:

1. The collection system, a quartz fiber filter and XAD-4 resin in series, can be used to collect both PAH and nicotine in indoor air.
2. The extraction method, Soxhlet extraction with dichloromethane followed by ethyl acetate can quantitatively remove both PAH and nicotine from XAD-4 resin.
3. The analysis method, positive chemical ionization gas chromatography/mass spectrometry (PCI GC/MS) operated in the multiple ion detection (MID) mode, can be used to determine both PAH and nicotine.

SECTION 3

RECOMMENDATIONS

Because XAD-4 resin has better sampling efficiency for nicotine than does XAD-2 resin and both adsorbents show comparable sampling efficiency for PAH, quartz fiber filters and XAD-4 resin are recommended for future field studies. The recommended sample preparation procedure is Soxhlet extraction with dichloromethane followed by ethyl acetate. The positive chemical ionization gas chromatography/mass spectrometry (PCI GC/MS) method operated in the multiple ion detection (MID) mode is also recommended for use in future studies to determine both PAH and nicotine.

SECTION 4

EXPERIMENTAL PROCEDURES

PREPARATION OF ADSORBENTS

The pre-cleaned XAD-2 resin was purchased from Supelco. The pre-cleaned resin was extracted with dichloromethane for 16 hours and dried with an ultra-pure nitrogen gas stream. The clean XAD-2 resin was packed in a glass cartridge at the bed depth of 2 in (Chuang et al., 1987). The weight of XAD-2 resin per cartridge was about 55 g.

The XAD-4 resin was purchased from Supelco. Various combinations of solvents were tried to clean the XAD-4 resin by Soxhlet extraction. These methods are summarized in Table 4.1. Because method 4 effectively removes the interfering components and the background PAH from XAD-4 resin, this method was used in most of the experiments conducted in this project. After extraction, the clean XAD-4 resin was packed similarly to the XAD-2 resin. The bed depth was 2 in. and the mass was about 100 g.

EXTRACTION EFFICIENCY STUDY

The spiking solution was prepared in dichloromethane at either 25 or 50 ng/μl concentration levels (Table 4.2). Two spiking methods were carried out as follows:

1. Solvent spike--injection of 200 μl of the spiking solution into the solvent reservoir before extraction.
2. Matrix spike--injection of 200 μl of the spiking solution into the clean XAD-4 resin before extraction.

Different solvents were evaluated with these two spiking methods. The

solvents used are summarized in Table 4.3. After spiking, the extractions were carried out for 16 hr. Prior to concentration, the extracts were filtered through clean, pre-wet quartz fiber filters. The extracts were concentrated to about 1 ml by Kuderna-Danish (K-D) evaporation and were analyzed by gas chromatography/mass spectrometry (GC/MS).

TABLE 4.1 CLEANUP METHODS FOR XAD-4 RESIN

Method	Extraction Solvent	Extraction Time, hr
1	Dichloromethane	16
2	Acetone	8
	Dichloromethane	16
3	Ethyl acetate	16
	Dichloromethane	16
4	Methanol	16
	Ethyl acetate	16
	Dichloromethane	16

TABLE 4.2 THE SPIKING SOLUTION USED IN THE EXTRACTION EFFICIENCY STUDY

Compound	Concentration, ng/μl(a)
Naphthalene	25
Nicotine	50
Acenaphthylene	25
Phenanthrene	25
Anthracene	25
Pyrene	25
Fluoranthrene	25
Benz[a]anthracene	25
Chrysene	25
Benzo[a]pyrene	25

(a) An aliquot of 200μl was used in each experiment.

TABLE 4.3 TYPES OF SOLVENTS EVALUATED IN THE EXTRACTION EFFICIENCY STUDY

Method	Solvent Combinations
Solvent spike	Dichloromethane 0.01% Trimethylamine in dichloromethane Ethyl acetate 0.01% Trimethylamine in ethyl acetate
Matrix spike	Dichloromethane Ethyl acetate 0.01% Trimethylamine in ethyl acetate 0.01% Pyridine in ethyl acetate Dichloromethane followed by 0.01% Pyridine in ethyl acetate Dichloromethane followed by ethyl acetate

SAMPLING EFFICIENCY STUDY

Two prototype indoor air samplers (B and C) used in the previous study (Chuang et al., 1987) were run for five sampling days in an office room at Battelle. These two samplers were placed parallel to each other and separated from each other by about 1 ft. Quartz fiber filter and XAD-2 resin in series was used in one sampler, and quartz fiber filter and XAD-4 resin in series was used in the other sampler. Prior to sampling, aliquots (80 μl) of the perdeuterated solution (Table 4.4) were spiked onto both XAD-2 and XAD-4 cartridges. Then the air was sampled for about 24 hr. The sampling conditions are summarized in Table 4.5.

The samplers were exposed to cigarette smoke during the sampling period at uneven intervals for the first four tests. Table 4.6 indicates the timing of cigarette burning. In each case, a total of 25 cigarettes (Marlboro and Marlboro lights) were lit and allowed to burn to the filter

TABLE 4.4 THE SPIKING SOLUTION USED IN THE SAMPLING EFFICIENCY STUDY

Compound	Concentration, ng/μl(a)
D_8-Naphthalene	25
D_{10}-Phenanthrene	25
D_{12}-Chrysene	25
D_{12}-Benzo[a]pyrene	25
D_3-Nicotine	25

(a) An aliquot of 80 μl of this solution was spiked onto each XAD-2 and XAD-4 resin prior to sampling.

TABLE 4.5 SUMMARY OF THE SAMPLING CONDITIONS

Test (a)	Sample Code (b)	Time (c)	Duration hr	Average Flow, L/min	Volume, m^3
1	XAD2-1B	1440	23.50	267.9	377.7
	XAD4-1C	1440	23.50	259.4	365.8
2	XAD4-2B	1500	23.08	237.9	329.4
	XAD2-2C	1500	23.08	245.3	339.7
3(d)	XAD2-3B	1435	25.00	272.8	409.2
	XAD4-3C	1435	25.00	264.5	396.7
4	XAD4-4B	1620	24.00	248.9	358.4
	XAD2-4C	1620	24.00	261.1	376.0
5	XAD2-5B	1440	24.00	226.5	326.3
	XAD4-5C	1440	24.00	226.5	326.3

(a) A totalof 25 cigarettes were smoked during each sampling period from Test 1 to Test 4; no cigarettes were smoked during the Test 5 sampling period.
(b) B or C denotes sampler B or sampler C.
(c) At the start of sampling period.
(d) A shelf was painted in the office during this sampling period.

The samplers were exposed to cigarette smoke during the sampling period at uneven intervals for the first four tests. Table 4.6 indicates the timing of cigarette burning. In each case, a total of 25 cigarettes (Marlboro and Marlboro lights) were lit and allowed to burn to the filter of the cigarettes. The tray containing the cigarettes was located about 5 ft from the sampler inlets. In the fifth test, the samplers were not exposed to cigarette smoke. All the XAD-2 and XAD-4 samples from these tests were Soxhlet extracted by dichloromethane followed by ethyl acetate and K-D concentrated to about 1 ml for GC/MS analysis.

TABLE 4.6 SAMPLER CIGARETTE EXPOSURE TIME

Samples	Cigarettes Burned
XAD2-1B, XAD4-1C	5 at 1500; 5 at 1610; 5 at 1700; 5 at 1755; 5(a) at 0800
XAD4-2B, XAD2-2C	4 at 1505; 6 at 1605; 5 at 1710; 5 at 0745; 5 at 1120
XAD2-3B, XAD4-3C	5 at 1435; 5 at 1645; 5 at 0750; 5(a) at 0930; 5(a) at 1135
XAD4-4B, XAD2-4C	5 at 1623; 5 at 1710; 5 at 1530; 10 at 1600

(a) Denotes Marlboro "Lights".

GAS CHROMATOGRAPHY/MASS SPECTROMETRY

The standard solutions and the sample extracts were analyzed by GC/MS with either positive chemical ionization (PCI) or electron impact (EI) conditions.

A Standard Finnigan 4500 GC/MS or an Extranuclear MS equipped with a Hewlett Packard GC were used. An Ultra No. 2 cross-linked 5 percent phenylmethyl silicone fused silica capillary column was used as the GC column and the GC column outlet was located in the MS ion source. The data acquisition and processing system employed in both MS systems was a Finnigan Incos 2300 data system. The GC/MS operation conditions are given in Table 4.7.

TABLE 4.7 GC/MS OPERATING CONDITIONS

GC parameters	
Column	Ultra No. 2 fused silica, cross-linked, 5% phenyl methyl silicone, 50 m x 0.32 mm (i.d.) x 0.51μm (film thickness) or 30 m x 0.32 mm (i.d.) x 0.17 μm (film thickness)
Carrier	CH_4 (Finnigan) or He (Extranuclear) Velocity 50 cm/s at 250°C
Injection	1-2 μl, splitless mode at 300°C
Program	60°C hold for 2 min.; programmed to 290°C at 8°C/min ; hold for 15 min
MS parameters	
Mass Scan	45 to 440 amu at 1 s/scan in EI, full scan mode 100 to 440 amu at 1 s/scan in PCI, Full scan mode molecular ions monitored by PCI, multiple ion detection mode.
Filament Emission Current	0.3 ma (Finnigan) or 1000 ma (Extranuclear)
Signal Amplification	10^{-7} amp/volt with approximately 10^5 electron multiplier gain
EI Condition	70 eV
PCI Condition	CH_4 at 1.0 torr; 150 eV.

Sample extracts from the extraction efficiency study were analyzed by EI in the full scan mode with GC/MS (Extranuclear) to determine the recoveries of the spiking compounds. An aliquot (200 μl) of the spiking solution (Table 4.2) was diluted to 1 ml with dichloromethane and used as a standard solution for GC/MS analysis. Because nicotine is susceptible to losses on glass or active sites on the GC column, two internal standards were used: D_3-nicotine for nicotine, and 9-phenylanthracene for PAH. Prior to analysis the internal standards 9-phenylanthracene and D_3-nicotine were added to the standard solution and sample extracts at constant concentration levels of 10 ng/μl. The determination of each target compound was based on the correct mass spectrum and the correct retention time relative to the internal standards as determined from the standard analyses. The standard solution was analyzed concurrently with the sample extracts. The order of analysis was:

standard, sample, sample, sample, sample, standard

until all analyses of the sample extracts were complete. The response factor of each target compound was calculated from the analyses of the standard solutions using the following equation:

$$Rf = \frac{As\ Cis}{Ais\ Cs}$$

where Rf = response factor of the target compound
Cs = concentration of the target compound, ng/μl
As = molecular ion area of the target compound
Cis = concentration of each internal standard, 10 ng/μl
Ais = molecular ion area of each internal standard.

The daily average response factor of each target compound was used to quantify the target compounds in the sample extracts analyzed on the same day.

Sample extracts from the sampling efficiency study were analyzed by PCI GC/MS (Finnigan) in MID mode to determine the target compounds. The standard solution contained 2 ng/μl of the spiking solution (Table 4.4), 2 ng/μl of target native PAH, and 5.0 ng/μl of native nicotine. Because D_3-nicotine was used in the spiking solution, only one internal standard, 9-phenylanthracene, was used to quantify both nicotine and PAH. The

internal standard was added to the standard solution and sample extracts prior to analysis at constant concentration levels of 1.0 ng/μl. Based on the standard analyses, the estimated detection limit for nicotine and PAH is about 0.01 ng on column from the PCI GC/MS in the MID mode.

The determination of target PAH compounds were based on the correct protonated molecular ion and the correct retention time relative to the internal standard similarly as described in the extraction efficiency study. High levels of nicotine were detected in the samples collected under smoking conditions resulting in saturation of the protonated molecular ion (M+1)+, threrefore a secondary ion mass of lesser intensity $(M+C_2H_5)^+$ was monitored and used for quantification. For some extracts, the secondary ion mass of nicotine was also saturated; those extracts were diluted to a factor of 20 and were reanalyzed by GC/MS. Another standard solution containing 0.1 ng/μl of the spiking compounds, 1.0 ng/μl of the native PAH and 5.0 ng/μl of nicotine was prepared and used to quantify these diluted samples.

SECTION 5

RESULTS AND DISCUSSION

The cleanup method used for XAD-2 resin does not remove all of the background components, such as naphthalene, from XAD-4 resin. Therefore, various combinations of solvents were evaluated for cleaning XAD-4 resin. The results showed that Soxhlet extraction with methanol, ethyl acetate and dichloromethane sequentially can remove most of the background components from XAD-4. Only small quantities of naphthalene were found in XAD-4 resin with this cleanup method.

The results of the extraction solvent spike study are presented in Table 5.1. To minimize the loss of nicotine to glass surfaces, all glassware was rinsed with 1% pyridine in dichloromethane. As shown in Table 5.1, good recoveries were obtained for the spiked PAH and nicotine from the solvent spike experiments. This finding indicated that the losses of target compounds through sample handling and concentration are negligible. It was noted that during the concentration of 0.01% trimethylamine in dichloro-methane, white precipitates were formed. Precipitates were not detected for 0.01% trimethylamine in ethyl acetate. This observation suggested that ammonium salts were formed between trimethylamine and dichloromethane during concentration. Thus this solvent system was excluded from the matrix spike experiment.

The results of the extraction matrix spike are in Table 5.2. The results indicated that good recoveries of PAH were obtained from the XAD-4 resin when dichloromethane was used as the extracting solvent. But only 27 percent of nicotine was recovered from the XAD-4 resin. The recovery of nicotine improved to greater than 90 percent with ethyl acetate. The recoveries of some PAH from the XAD-4 resin, such as acenaphthylene and anthracene, were only from 70 to 60 percent. The recoveries of these PAH did not improve when basic ethyl acetate was used. Thus two-step extractions were evaluated. These consisted of dichloromethane followed

TABLE 5.1 RECOVERY DATA FOR PAH AND NICOTINE FROM EXTRACTION SOLVENT SPIKE STUDY

Compound	Percent Recovery, %			
	Dichloromethane[a]	0.01% Trimethylamine in Dichloromethane	Ethyl acetate[a]	0.01% Trimethylamine[c] in Ethyl acetate
Naphthalene	88	NA[b]	100	73
Nicotine	97	NA	110	81
Acenaphthylene	89	NA	84	96
Phenanthrene	94	NA	100	99
Anthracene	91	NA	96	100
Fluoranthene	91	NA	90	99
Pyrene	92	NA	90	100
Benz[a]anthracene	95	NA	82	100
Chrysene	95	NA	82	100
Benzo[a]pyrene	94	NA	97	96

(a) Average values from duplicate experiments.
(b) The recovery data are not available due to white precipitates forming during concentration.
(c) Only one experiment performed.

TABLE 5.2 RECOVERY OF PAH AND NICOTINE FROM EXTRACTION MATRIX SPIKE STUDY

Compound	Dichloromethane[a]	Ethyl acetate[a]	0.01% Trimethylamine[a] in Ethyl acetate	0.01% Pyridine[b] in Ethyl acetate	Dichloromethane[b] followed by 0.01% Pyridine in ethyl acetate	Dichloromethane[b] followed by ethyl acetate
Naphthalene	>100	>100	>100	96	100	100
Nicotine	27	110	110	100	85	95
Acenaphthylene	95	63	64	79	76	85
Phenanthrene	98	100	100	88	86	100
Anthracene	93	73	73	80	80	94
Fluoranthene	91	94	92	88	92	100
Pyrene	91	92	91	75	92	100
Benz[a]anthracene	92	91	89	80	90	100
Chrysene	93	91	83	75	92	100
Benzo[a]pyrene	97	70	82	64	93	100

(a) Average values from duplicate experiments.
(b) Only one experiment performed.
(c) High background levels of naphthalene found in XAD-4 resin.

by either 0.01% pyridine in ethyl acetate or 100% ethyl acetate. Overall, good recoveries for both PAH and nicotine were obtained, as shown in Table 5.2. The recoveries of naphthalene were greater than 100 percent in some cases because the evaluation of XAD-4 cleanup method and the extraction matrix spike study were conducted concurrently. Significant amounts of background naphthalene were found in the XAD-4 resin when the first three methods were used to clean the resin. Therefore, greater than 100 percent recoveries of naphthalene were observed when XAD-4 resin was cleaned by these methods.

The PAH and nicotine data for the XAD-2 samples from the sampling efficiency study are summarized in Tables 5.3 through 5.7. The recoveries of perdeuterated PAH and D_3-nicotine from these samples are given in Table 5.8. The filter samples from this study were not analyzed.

Even though the two samplers were placed in parallel during sampling, we expected about 20% variations based on sampling and analysis of parallel samples from previous studies. As shown in these tables, most PAH levels found in the XAD-2 and the XAD-4 samples are indistinguishable from each other indicating both XAD-2 and XAD-4 resin have similar sampling efficiency for PAH. However, levels of nicotine found in XAD-4 samples were higher than those in the corresponding XAD-2 samples. These results suggest that XAD-4 resin has better collection efficiency for nicotine than XAD-2 resin. As expected, higher levels of PAH and nicotine were found in room air when cigarettes were smoked in the room.

In general, good recoveries were obtained for most of the spiked perdeuterated PAH. The recoveries of D_3-nicotine could not be accurately calculated because of interference peaks detected in the samples collected under the cigarette smoking condition. However, under the non-smoking condition, slightly better recovery of D_3-nicotine was observed in the XAD-4 sample compared to the XAD-2 sample. Overall, the results suggest that XAD-4 resin is a better choice of adsorbent to collect nicotine than is XAD-2 resin.

The standard solution containing PAH and nicotine was analyzed by both EI and PCI GC/MS methods. As expected, the PCI method provides better detection sensitivity for nicotine than the EI method. The

detection sensitivities for PAH with both methods are very similar. Fused silica capillary columns with two film thicknesses (0.17 um and 0.50 um) were evaluated. Better detection sensitivity for nicotine was detected with the thinner film column (0.17 um). Analysis of the indoor air samples showed that the PCI GC/MS method can quantitatively determine PAH and nicotine in XAD-2 and XAD-4 samples without a cleanup step. The sensitivity for the analysis of PAH and nicotine was enhanced significantly in the MID mode compared to the full scan mode. Therefore, PCI GC/MS operated in MID is recommended in the future.

TABLE 5.3 LEVELS OF PAH AND NICOTINE FOUND IN XAD-2 AND XAD-4 SAMPLES COLLECTED SIMULTANEOUSLY

Compound	Concentration, ng/m^3	
	XAD2-1B [a]	XAD4-1C[a]
Naphthalene	1400	1499
Nicotine	2000	9700
Acenaphthylene	37	33
Phenanthrene	190	190
Anthracene	12	13
Fluoranthene	21	20
Pyrene	13	12
Benz[a]anthracene	1.4	1.1
Chrysene	3.1	2.5
Benzo[a]pyrene	ND[b]	ND[b]

(a) The sampling conditions are described in Table 4.5.

(b) Not detected.

TABLE 5.4 LEVELS OF PAH AND NICOTINE FOUND IN XAD-2 AND XAD-4 SAMPLES COLLECTED SIMULTANEOUSLY

Compound	Concentration, ng/m^3	
	XAD2-2C[a]	XAD4-2B[a]
Naphthalene	1800	1900
Nicotine	3700	25000
Acenaphthylene	44	54
Phenanthrene	270	260
Anthracene	15	18
Fluoranthene	32	33
Pyrene	21	23
Benz[a]anthracene	1.5	1.9
Chrysene	3.5	3.6
Benzo[a]pyrene	ND[b]	ND[b]

(a) The sampling conditions are described in Table 4.5.
(b) Not detected.

TABLE 5.5 LEVELS OF PAH AND NICOTINE FOUND IN XAD-2 AND XAD-4 SAMPLES COLLECTED SIMULTANEOUSLY

Compound	Concentration, ng/m^3	
	XAD2-3B[a]	XAD4-3C[a]
Naphthalene	1700	1800
Nicotine	9000	28000
Acenaphthylene	46	40
Phenanthrene	240	210
Anthracene	13	12
Fluoranthene	27	23
Pyrene	20	17
Benz[a]anthracene	1.5	1.9
Chrysene	4.2	3.8
Benzo[a]pyrene	ND[b]	ND[b]

(a) The sampling conditions are described in Table 4.5
(b) Not detected.

TABLE 5.6 LEVELS OF PAH AND NICOTINE FOUND IN XAD-2 AND XAD-4 SAMPLES COLLECTED SIMULTANEOUSLY

Compound	Concentration, ng/m^3	
	XAD2- 4C[a]	XAD4-4B[a]
Naphthalene	1300	2000
Nicotine	16000	33000
Acenaphthylene	32	47
Phenanthrene	190	210
Anthracene	11	14
Fluoranthene	21	24
Pyrene	14	17
Benz[a]anthracene	1.7	2.0
Chrysene	2.9	3.9
Benzo[a]pyrene	ND[b]	ND[b]

(a) The sampling conditions are described in Table 4.5.
(b) Not detected.

TABLE 5.7 LEVELS OF PAH AND NICOTINE FOUND IN XAD-2 AND XAD-4 SAMPLES COLLECTED SIMULTANEOUSLY

Compound	Concentration, ng/m^3	
	XAD2-5B (a)	XAD4- 5C (a)
Naphthalene	1200	1200
Nicotine	520	600
Acenaphthylene	10	12
Phenanthrene	80	78
Anthracene	3.5	3.1
Fluoranthene	11	13
Pyrene	6.6	7.0
Benz[a]anthracene	0.6	0.5
Chrysene	0.7	0.7
Benz o[a]pyrene	ND(b)	ND(b)

(a) The sampling conditons are described in Table 4.5.
(b) Not detected.

TABLE 5.8 RECOVERY DATA FOR PERDEUTERATED PAH AND NICOTINE FROM XAD-2 AND XAD-4 SAMPLES

Compound	Recovery, % (a)									
	XAD2-1B	XAD4-1C	XAD2-2C	XAD4-2B	XAD2-3B	XAD4-3C	XAD4-4C	XAD4-4B	XAD2-5B	XAD4-5C
D_8-Naphthalene	100	100	110	120	86	92	100	100	100	100
D_{10}-Phenanthrene	100	98	110	110	110	100	110	110	100	100
D_{12}-Chrysene	94	84	100	100	110	100	100	100	97	95
D_{12}-Benzo[a]pyrene	80	78	100	100	100	100	100	110	79	86
D_3-Nicotine	INT.(b)	INT.(b)	INT.(b)	INT.(b)	INT.(b)	INT.(b)	INT.(b)	INT.(b)	80	110

(a) The sampling conditions are described in Table 4.5.
(b) Interference peaks coelute with D_3-nicotine and the recovery cannot be calculated.

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